Charm and Bottom Quark Production Cross Sections Near Threshold *

J. Smith† *and R. Vogt*

Next-to-leading order calculations of charm production are large compared to the Born cross section, suggesting that further higher order corrections are substantial. Near threshold large logarithms in the perturbative expansion can arise from an imperfect cancellation of the soft-plus-virtual (S+V) terms, which must be resummed. An approximation of these terms was used to resum the leading logarithms to all orders in perturbation theory [1]. The method relies on the proportionality of the higher order terms to the Born cross section. A cutoff parameter, μ_0, is introduced to keep the result finite. A strong dependence on μ_0, implies that the cross section requires nonperturbative contributions.

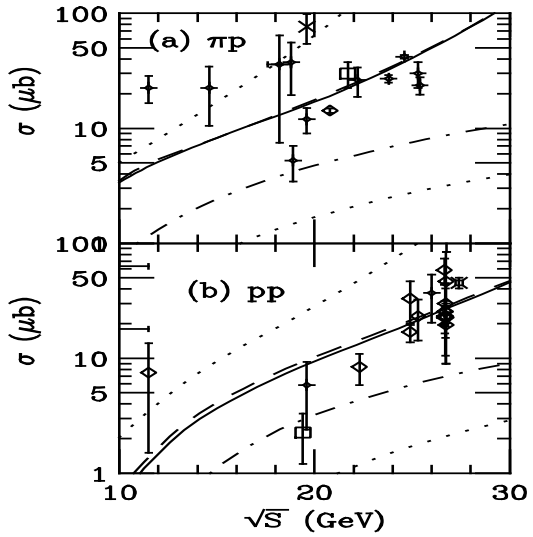

Figure 1: We show the $c\bar{c}$ cross sections, $\sigma^{\rm res}$ (solid), $\sigma^{\rm imp} = \sigma^{\rm res} + \sigma^{\rm NLO}|_{\rm exact} - \sigma^{\rm NLO}|_{\rm app}$ (dashed), and $\sigma^{\rm NLO}|_{\rm exact}$ (dot-dashed), in (a) $\pi^- p$ and (b) pp interactions. Extreme values of $\sigma^{\rm res}$ are shown in the dotted lines.

Because m_c is relatively small, $1.2 \leq m_c \leq 1.8$ GeV/c^2, charm production must be treated with some care. The only consistent NLO evaluation of the pion and proton parton densities is GRV HO [2], in the $\overline{\rm MS}$ scheme. This set also has a small initial scale so that $\mu = m_c = 1.5$ GeV/c^2 is used. We find that resummed cross section, $\sigma^{\rm res}$, in the $q\bar{q}$ channel in the $\overline{\rm MS}$ scheme converges for $\mu_0 \approx 0.15 m_c$ while the gg channel, with its larger color factor, converges for $\mu_0 \approx 0.35 m_c$. The ratios μ_0/m_c agree with the convergence ratios for bottom and top production.

Figure 1 shows that the perturbative expansion no longer converges at higher energies, since $\sigma^{\rm res}$ and $\sigma^{\rm imp}$ increases with energy faster than $\sigma^{\rm NLO}|_{\rm exact}$. The upper dotted curves, with $\mu = m_c = 1.3$ GeV/c^2, increase faster than $\sigma^{\rm res}$, implying that the resummation breaks down at lower energies for lighter masses. The lower dotted curves are calculated with $\mu/2 = m_c = 1.8$ GeV/c^2 and the MRS D$-'$ proton and SMRS P2 pion distributions [3]. The larger quark mass requires a larger μ_0 for convergence.

[1] E. Laenen, J. Smith, and W.L. van Neerven, Nucl. Phys. **B369** (1992) 543.
[2] M. Glück, E. Reya and A. Vogt, Z. Phys. C53 (1992) 127; Z. Phys. C53 (1992) 651.
[3] A.D. Martin, W.J. Stirling and R.G. Roberts, Phys. Lett. **B306**, 145 (1993); P.J. Sutton, A.D. Martin, R.G. Roberts and W.J. Stirling, Phys. Rev. **D45** (1992) 2349.

*LBL-38282 and ITP-SB-95-60; Z. Phys. **C** in press.
†Institute for Theoretical Physics, State University of New York at Stony Brook